clear belt thus formed. Immediately afterwards heavy rain-clouds settled hopelessly down and concealed the sky for the rest of the night.

Dun Echt Observatory:
1885, *Nov.* 30.

The Great Shower of Andromedes, November 26, 27, 28, *and* 30, 1885. By W. F. Denning.

The nights of November 24 and 25 were overcast here.

On the evening of November 26 heavy rain fell before $8^h\ 30^m$, then the atmosphere cleared somewhat, and I counted 21 shooting stars in the ensuing 15 minutes. Of these, 19 were *Andromedes*. The sky then clouded again, but later on, through temporary breaks, I saw 42 additional meteors, including 41 *Andromedes*. I estimated that with a clear sky the hourly number visible for one observer was about 130. The radiant point was at 26°+44°, but the observed tracks did not come precisely to a focus. It was necessary to adopt a radiant area of several degrees diameter in order to satisfy the directions. No observations were possible after $12^h\ 30^m$ on November 26; clouds and occasional storms interfered until daylight.

On November 27 the sky in the early evening was much involved in clouds and haze, but before the twilight had disappeared, and before any stars could be distinguished, I observed several fine *Andromedes* with their typical spark-trains and very slow motions. It was at once evident that since the preceding night the display had developed into one of great richness. As the sky grew darker the number of meteors rapidly increased, but the heavens continued to be so much involved in cloud that the real strength of the shower could not be adequately determined. I counted the meteors in intervals of five minutes as follow:—

		No. seen.	State of sky.
h m	h m		
5 10 to	5 15	33	Very cloudy and hazy. Only *Capella* and two or three other bright stars visible.
5 25	5 30	126	Sky very much overcast.
5 55	6 0	105	Sky more overcast, very few stars visible.
6 25	6 30	222	Clearer, but still hazy and the stars looking dim.

No regular observations could be obtained after $6^h\ 40^m$ owing to clouds and rain, which continued almost unabated

during the whole night. Before $9^h\ 15^m$, however, there occurred one or two transient breaks, and meteors were observed to be falling thickly, but only momentary glimpses were possible.

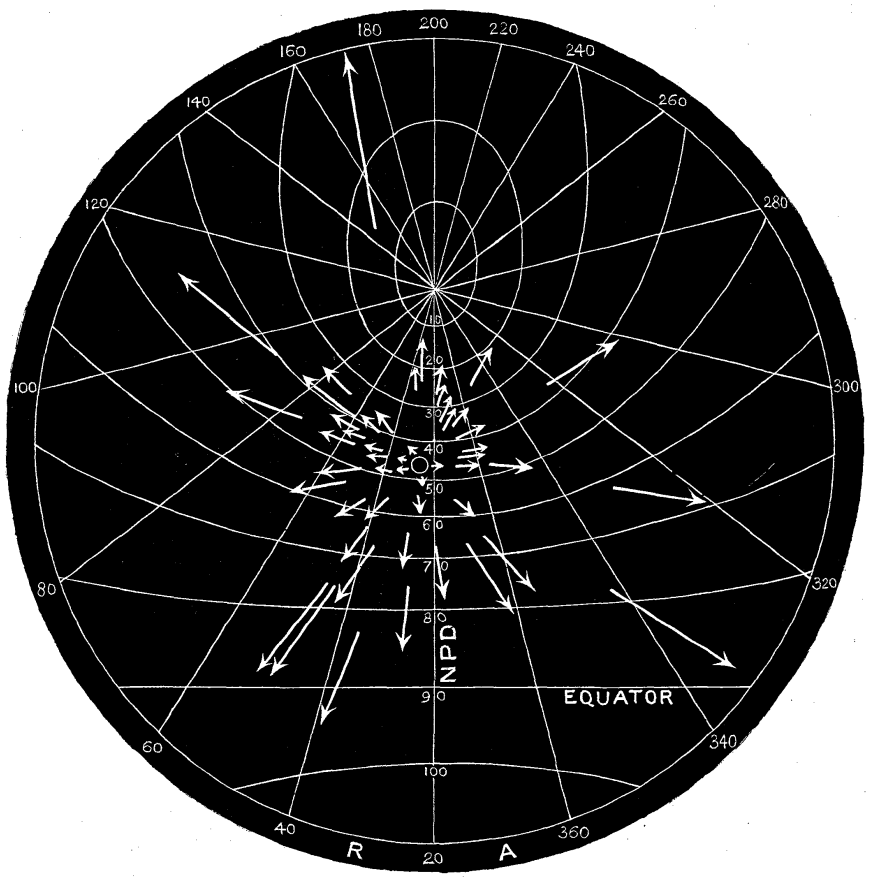
With a pefectly clear sky the number visible within the sphere commanded by one observer must have been equivalent to more than 5,000 per hour, judging from the richness of the phenomenon so imperfectly seen here between 6^h and $6^h\ 30^m$. The display was probably therefore quite equal to that of November 27, 1872. When clouds enforced the suspension of my observations, soon after $6^h\ 30^m$, the display was evidently intensifying; the meteors were beginning to fall in what may be described as intermittent volleys of 5, 7, or 10, and even more.

The radiant point was very inexact. In many cases I found that very accurately observed paths deviated several degrees from the mean. The area of radiation must have been fully 7° in diameter to accommodate the discordances in the flights. The centre was at 24°+44°, but I saw several very short paths from a point south of γ *Andromedæ*. I noted many of the meteors with the utmost care in order to assure myself of the diffuseness of radiation, and it was found impossible to get a sharply defined position. The contrary effect was indeed so obvious as to arrest the eye whenever simultaneous bursts of about six or seven meteors took place near the radiant. It was then seen that the collective flights were not symmetrical emanations from a central point. They rather appeared to be discharged in a loose, disjointed fashion from a comparatively large space on the N.W. region of γ *Andromedæ*, and just perhaps enveloping that star within its limits. With regard to this peculiarity the shower shows a departure from the rule I have found to obtain during the observation of minor streams. The tracks usually intersect almost at a point, and I believe that diffuse and uncertain radiation has a tendency to disappear altogether in cases where the observations are very exact. But every effort towards accuracy only exhibited the diffused radiation of the *Andromedes* in a more unmistakable manner, and proved it to be an inseparable feature of the shower's appearance.

Both on November 26 and 27 there was a tolerably large number of bright meteors. The very unfavourable weather here enabled me to make no comparative observations as to magnitude. It is certain that very few of the more minute *Andromedes* could be descried in a sky where stars below the 4th magnitude were hidden nearly the whole time. On November 26 I recorded several meteors as bright as *Jupiter*, and near to the maximum on November 27, some were seen brighter than *Venus*—many rivalled *Jupiter*. They invariably traversed short paths with very slow motions, and became extinct in evolved streams of yellowish sparks. Noting their visible aspects particularly, the conclusion seemed obvious that these meteors are formed of very

soft materials, which expand while incalescent, and are immediately crumbled and dissipated into exiguous dust. The resistance of the atmosphere upon some of the brightest of them appeared to be so effectual that they came almost to a standstill, and then disappeared with material and velocity alike spent.

On November 26 and 27 I noted about ten meteors of the class usually designated "sporadic." * Of these meteors, five were directed from a radiant point in *Cepheus* at 332°+58°. This has been observed before (though somewhat to the north of my position) by Dr. Konkoly on November 28, 1872, at 372°+63°, and by Mr. Sawyer on November 24, 1878, at 330°+63° (see *Monthly Notices*, vol. xl. p. 362, and *American Journal of Science and Arts*, vol. xvii, June 1879, Radiant No. 26). There is little doubt these are identical, the resemblance in position and epoch being very close.



Shower of *Andromedes*, 1885, Nov. 26 and 27. R.A. 25°, Dec. 44° N.
(W. F. Denning.)

The following are a few of the paths registered here on November 26 and 27 :—

* The term hardly seems to me a commendable one, though undoubtedly useful to conceal our ignorance of the contemporary streams supplying meteors unconformable to any special display that may be under observation.

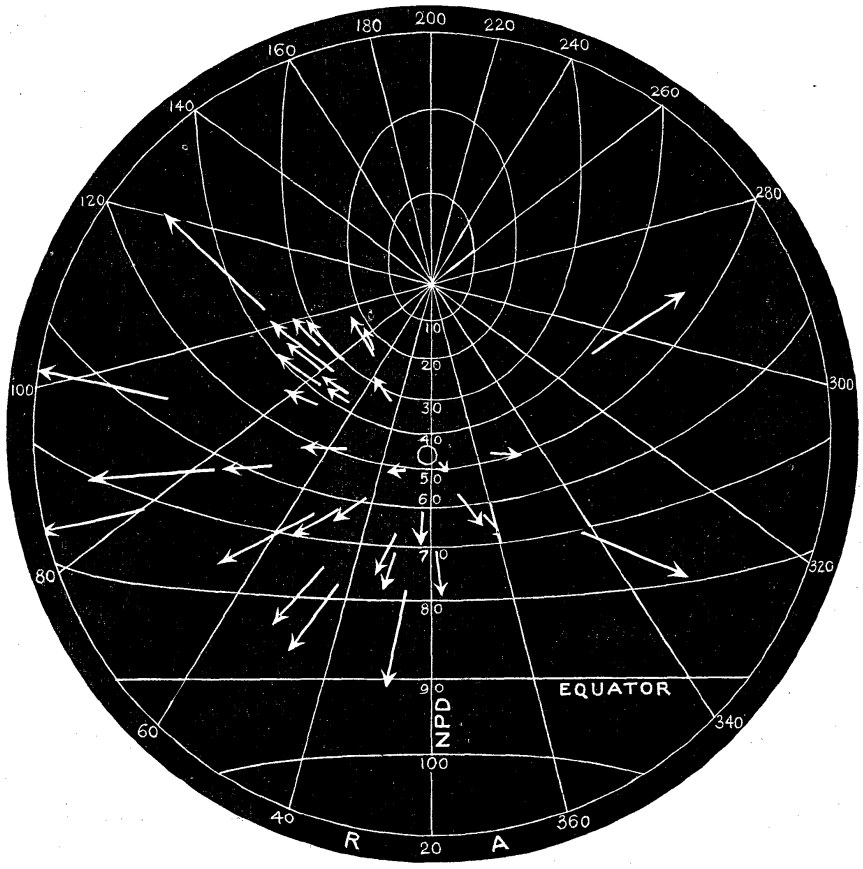
Date	Time	Mag.	Path Length. From		To		Notes.
	h m		°	°	°	°	
Nov. 26	8 42	4	48	+40	61	+36 ...11	V. slow, thick train.
26	8 51	1	26	67	26½	+76 ... 9	Very very slow, thick train.
26	9 47	1	94	51	112	46 ...13	Slow.
26	10 9	4	158	73½	177	60½...14½	V. slow, flash & train.
26	10 14	1	321	54	302	49 ...13	Slow, thick train.
26	10 33	1	46	13	52	2½...11	Very slow, train.
Nov. 27	5 19	1	15½	35	9	30½...17	,, ,,
27	5 22	♀	62	52	85	50½...14½	,, ,,
27	5 22	1	31	43	33½	42 ... 2	,, ,,
27	5 24	1	23	40½	21	39 ... 2	,, ,,
27	5 29	♀	20	25	18½	13 ...12	Slow, thick train.
27	5 31	1	3	42	347	38½...13	,, ,,
27	5 41	1	24	35½	22	31 ... 5	V. slow, thick train.
27	5 52	1	12	44	359½	42½... 9	,, ,,
27	6 10	1	5	46	354	45 ... 8	Slow, thick train.
27	6 12	1	7	20	1½	9 ...12	,,
27	6 17	1	351	64	326	66½...11	,,
27	6 17	1	15	60½	7½	66 ... 7	,,
27	6 34	1	10	54	356½	59 ... 9	,,
27	9 1	1	20¼	44½	18	44½... 1½	V. slow, thick train.

On November 28 the sky was magnificently clear until the moon rose at about $11^h\ 30^m$. Watching for about four hours in the aggregate—between $6^h\ 15^m$–$8^h\ 30^m$ and $9^h\ 30^m$–$11^h\ 30^m$—I saw sixty-five shooting stars. The shower of *Andromedes* still continued though entirely shorn of its imposing character. I observed some fifty-five meteors from the radiant near γ *Andromedæ*, but they were nearly all extremely minute, and many of them would have passed unobserved but for the exceptional clearness of the atmosphere. About thirty were of the 5th or 6th magnitude, and I just caught several which I rated as 6½ magnitude. There was a marked absence of meteors from other showers during the evening, not more than about a dozen being recorded.

I expected to discover on the 28th some displacement capable of being defined in the position of the radiant, similar to that which affects the August *Perseids*, and which, to a greater extent, I observed in connection with the April *Lyrids* of the present year (*Nature*, No. 810, May 7, 1885, p. 5). In both these instances the change is in the direction of increasing R.A., but I find strong evidence amongst my results that the radiant of the *Andromedes* moves in the contrary direction. I append

several positions for comparison derived on the nights of November 26, 27, 28, and 30:—

	h m	h m	° °		h m	h m	° °
Nov. 26	8 38 to	8 57	26 + 44	Nov. 27	6 25 to	6 30	23 + 45
26	9 43	10 10	27 + 43	28	6 15	11 30	22 + 43½
26	11 50	11 59	26 + 43½	30	6 39	7 19	21 + 42½
27	5 0	6 0	24 + 43½				



Shower of *Andromedes*, 1885, Nov. 28. R.A. 22°, Dec. 43½° N.
(W. F. Denning.)

The position for the 28th was determined from thirty-five paths, and represents a much better-defined radiant than any of the others. The decidedly erratic character of the display on the 26th and 27th, as regards its focus of divergence, seemed to have disappeared, and the directions as I registered them on the 28th indicate a far more uniform point of intersection. My figures prove that this point is not stationary, but that it probably moves slowly to the westward.

On the 28th, at about $7^h\ 18^m$, I witnessed a curious outburst of very faint *Andromedes* in the region N. of α and β *Aurigæ*. Five meteors were noted here (three of which were very nearly simultaneous) in less than two minutes, and these were closely succeeded by three others, all nearly in the same positions. It cannot be regarded as any other than a singular coincidence that eight shooting stars, belonging to a shower yielding at the time certainly not more than twenty meteors per hour for one observer, should appear in the same identical region within a few minutes. From the number of meteors actually counted during the evening there were only fourteen *Andromedes* per hour, but this is unquestionably below the real figures, for many meteors are lost by an observer during the moments his attention is withdrawn from the heavens to register the paths of those seen, and this is a detail of the work which requires to be done deliberately and cautiously, for ten observed meteor tracks exactly reproduced on the chart, are worth more than a hundred wild and hurried observations. The latter are useless, as leading to doubts and complications, whereas every accurate meteor-path possesses a certain value.

At about midnight on the 28th storm clouds came up from the west, and at an early hour on the morning of the 29th rain began falling and continued without intermission for some thirty-four hours. Thus I had no opportunity of seeing anything on the night of the 29th, though constantly on the alert for an opening. The evening of the 30th, however, came in clear, and at $5^h\ 30^m$ I began a close watch of the region of *Andromeda*. During the first hour I observed six shooting stars belonging to minor showers. There was no sign from the radiant in *Andromeda*, and I concluded the display had become exhausted. But at $6^h\ 39^m$ I saw a faint, slow meteor close to θ *Cassiopeiæ*, and directed straight from the radiant. Ten minutes later another was recorded passing $\frac{1}{2}^\circ$ N. of the great nebula M 31, and between $7^h\ 5^m$ and $7^h\ 19^m$ I saw four others, all very slow, and with the usual trains and short paths. The radiant was well defined at $21^\circ + 42\frac{1}{2}^\circ$. Observations were continued until $10^h\ 16^m$, when clouds overspread the sky. During my watch of $4\frac{1}{2}$ hours forty-one meteors were seen, of which ten certainly, and two others possibly, were *Andromedes*. It was the chief shower observed during the evening, though two others were equally well determined in respect of the points of radiation, viz. at—

$60^\circ + 49^\circ$	6 very swift meteors.
$41 + 39$	4 swift meteors.

I saw a bright 2nd magnitude meteor perfectly stationary at the former point at $8^h\ 32^m$. It is coincident with one of the special instances of stationary radiation which I referred to

in detail in my paper in the *Monthly Notices*, December 1884, pp. 103–4.

The following night, December 1, was again clear, and watching the sky during the four hours between $5^h\ 45^m$ and $9^h\ 45^m$ I observed twenty-five shooting stars. The shower of *Andromedes* appeared to have become extinct; not a single path could be positively assigned to that radiant, though at $7^h\ 57^m$ I saw a very small, slow meteor crossing λ *Tauri* from the right direction, but it was so extremely faint that I regard it as uncertain. We may therefore fairly assume that on the night of December 1 the display had definitely ceased, and that, in the interval elapsed since the preceding night, the Earth had fully emerged from the stream.

On the night of December 4 observations were resumed, and forty-eight shooting stars seen in another four-hours' watch. There was no sign of any radiation from γ *Andromedæ*, though I registered two bright slow meteors with thick trains from the point $9° + 33°$, which represents quite a distinct shower. (See *Monthly Notices*, Dec. 1884, p. 110, Radiant No. 9.)

On December 7 thirty shooting-stars were recorded in $3\frac{1}{2}$ hours. At $6^h\ 46^m$ I saw a very short, quick meteor, probably near a radiant almost identical with the *Andromedes*. I had seen two additional meteors of the same character, one on November 28, the other on November 30; and the combined paths indicate the radiant at $19° + 43\frac{1}{2}°$. There is possibly a feeble stream of hyperbolic meteors encountering the Earth at nearly the same date and position as the meteors of Biela's Comet. Two of the paths referable to the former shower were so short, and presumably so close to their radiant, that there can hardly be a doubt of its existence. These were as follows:—

	h m	Mag.	Path.		
Nov. 30	7 2	3	$11° + 40°$ to	$7° + 38\frac{1}{4}°$	Swift and short.
Dec. 7	6 46	3	$20 + 41$	$21 + 39$	V. quick, nearly stationary.

In the aggregate I saw 115 meteors on the four nights, November 28 and 30, December 1 and 4, not conformable to the true *Andromedes*, and from these I have derived the following radiant points which it may be useful to specify, as some of them will doubtless be reobserved during future watches for the *Andromedes*. I have not included my results for December 7, as the date is rather distant from the epoch of the great display:—

Ref. No.	Radiant. α δ	No. of Shooting Stars seen.	Notes.
1	$27° + 71°$	4	Very slow, faint.
2	$41 + 39$	6	Swift, short.
3	$44 + 56$	8	Very slow, faint.
4	$60 + 49$	8	Very swift.

Ref. No.	Radiant. α δ	No. of Shooting Stars seen.	Notes.
	° °		
5	79 + 24	5	Slow.
6	105 + 34	8	Swift. Geminids.
7	110 + 25	4	Rather slow.
8	143 + 48½	6	Very swift. Streaks.
9	194 + 43	8	„ „

The latter was the best shower. It is situated about 4° N. of *Cor Caroli*, and supplied several fine long meteors. That this stream should have rendered itself conspicuous, despite its unfavourable position (during nearly the whole of my observations), closely verging the northern horizon, proves it to be one of more than ordinary significance.

I have recently noticed great disparity in the relative velocities of neighbouring showers. In the preceding table of radiants it will be observed the meteors from No. 3 at 44° + 56° (near η *Persei*) were very slow, while those from No. 4 at 60° + 49° (near μ *Persei*) were "very swift." It is certain that if the meteors of these different streams become visible at nearly the same heights in the atmosphere, they must be moving with vastly different velocities. It will be important to further watch these swift meteors from radiants so distantly removed from the apex of the Earth's way.

The recorded duration of the recent display of *Andromedes* over at least five nights is remarkable when we remember the short-lived character of the shower on November 27, 1872. On the nights of the 25th and 26th November of that year I found meteors scarce, and the fact was confirmed by Mr. Jackson at Tooting. On the 28th I saw no lingering traces of the shower, and Mr. Greg at Buntingford, and several observers at Hawkhurst, in Kent, were similarly unsuccessful (*Nature*, No. 162, December 5, 1872, p. 104). If these observations are conclusive, the observed duration of the phenomenon of 1872 appears to have been limited to a single night. It could not have formed a display of any importance on either of the two nights preceding or following the maximum, though a distinct shower of these *Andromedes* appears to have been witnessed in America as early as November 24, 1872. They were watched by Mr. T. Hadley and Professors Twining and Newton at Newhaven between $7^h\ 30^m$ and 12^h, when their numbers were recorded as forty per hour for one observer, and the radiant point, as estimated by Professor Newton, was 2° or 3° N. of γ *Andromedæ* (*B. A. Report* for 1873, p. 387). This shower had, however, on the 25th declined to one-third its richness, as determined on the 24th, so that the display may probably have been due (especially when we regard the negative results obtained in England on the nights immediately prior to the 27th) to a closely outlying system which could hardly have been connected with the main

stream, from the utter absence of intermediate meteors on November 26. I believe that for the return of the present year we must allow at least seven days' duration; for when I first detected it on the evening of the 26th it had already attained considerable intensity. And the relative numbers counted on the 26th and 28th prove the decline to have been more rapid than the rise, so that had observations been possible before moonrise on the early evenings of the 24th and 25th, the shower would have been duly recognised, gaining intensity each night until it afterwards culminated in the brilliant maximum of November 27.

Bristol: 1885, *Dec.* 8.

La grande pluie des étoiles filantes du 27 Novembre 1885.

By F. Denza.

(*Communicated by the Secretaries.*)

La pluie extraordinaire des étoiles filantes du 27 Novembre 1872 s'est renouvelée cette année le même jour et à peu près avec la même intensité. D'après les télégrammes et les relations que nous avons reçus en grand nombre jusqu'à présent, il résulte que le phénomène en question a été remarqué dans toute l'Italie depuis les Alpes jusqu'à l'extrémité de la Sicile, et qu'il se produisit partout sous les mêmes formes. Il commença à la tombée du jour. A Tarente à 5^h du soir les étoiles jaillissaient et filaient en lignes si compactes, qu'elles perçaient de temps en temps l'obscurité déjà avancée de la nuit. A Palerme quelques-uns de nos anciens élèves ingénieurs comptérent 4600 météores de 5^h 15 à 6^h 30. A cette heure la pluie météorique se manifestait en plusieurs autres endroits avec une abondance tout à fait surprenante.

Dans notre Observatoire on commença à explorer le ciel à 6^h du soir (temps moyen de Rome). Nous avons suivi la même méthode que je suivis en 1872; les observations actuelles peuvent en conséquence être comparables avec celles d'alors. Comme j'eus déjà plusieurs fois l'occasion d'exposer cette méthode, je crois à propos de l'omettre ici. Je me bornerai à rapporter les résultats obtenus de 15 en 15 minutes, et afin de mieux éclaircir ma relation, je vais donner ci-dessous un tableau dont la seconde colonne indique le nombre des observateurs chaque quart d'heure; et la troisième l'état de l'atmosphère en dixième de ciel libre. La quatrième colonne contient le nombre des météores réellement comptés, et la dernière le nombre supputé des étoiles, c.-à.-d. le nombre qu'on aurait dû avoir par conjecture si les observateurs eussent été toujours au nombre de quatre et que le ciel eût été toujours serein.